Effect of breed and dietary protein and lysine levels on pork quality traits

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Abstract — **Pork is the most consumed meat all over the world. Intramuscular fat (IMF) has been shown to be positively related to quality of meat. Hence, the production of pork with higher amounts of IMF, without an increase in subcutaneous fat, would be highly desirable for the pig industry. This study was designed in order to investigate the effect of breed (Alentejano purebred *vs.* Large White x Landrace x Pietrain crossbred) and protein level (normal *vs.* reduced) with or without correction for lysine on meat quality, IMF, instrumental tenderness and optical measurements in pork *longissimus dorsi* muscle. Sixty intact male pigs with an initial and final average live weight of 60 ± 2 and 93 ± 2 kg, respectively, were used in this experiment. The IMF was extracted according to the Soxhlet method with previous acid hydrolysis. Loin pH and temperature were measured at 45 min and 24 h *postmortem* and colour lightness, redness and yellowness (L,* a* and b* values) at 24 h *postmortem*. Results showed a significant interaction (*P*<0.05) between breed and diet for IMF content (2.2-5.8 g/100 g muscle). Breed had a significant effect on pH and shear force (*P*<0.01), initial temperature (*P*<0.05) as well as on L* (*P*<0.001) and a* (*P*<0.01) values, while dietary protein and lysine levels had no influence. The relationship between IMF, shear force and meat colour are further discussed.**

Keywords — **Pork quality, Intramuscular fat, Shear force**

I. INTRODUCTION

Pork is one of the most consumed meats in the world, and thus, an important source of dietary fat [1]. It was suggested that the threshold levels of intramuscular fat (IMF) required for optimal eating quality range from 2% to 2.5% [2]. More recently, the National Pork Board in the US set the industry target for IMF between 2% and 4%, the minimum level reflecting satisfactory eating characteristics and the maximum level reflecting health concerns associated with excessive fat [3]. However, 84% pig carcasses of commercial breeds were characterized by a IMF content lower than 2%, which affected negatively the tenderness of pork [4]. Hence, different feeding strategies that could increase the amount of IMF would be advantageous to improve pork eating quality [5]. Earlier studies have shown that the IMF levels can be increased, with residual effect on subcutaneous fat deposition, by feeding low protein diets [6,7]. Moreover, feeding pigs with lysine deficient diet reduces protein synthesis and increases fat deposition [8].

Alentejano pig breed show low growth rates and very early maturing fat deposition and an excellent meat compared to crossbred pigs [9]. Thus, the objective of this study was to investigate the combined effect of breed and diet (whit different levels of protein and lysine) as a strategy for increasing IMF and improving meat quality characteristics on *longissimus dorsi* muscle of pork.

II. MATERIAL AND METHODS

This study was accomplished with sixty entire male pigs (30 Alentejano purebred and 30 Large White x Landrace x Pietrain crossbred) with a mean live body weight of 60 ± 2 kg. Before the beginning of the experiment, animals were housed and fed with the same conventional feed (based on starter and growth concentrates). Pigs were then divided into groups of 10 pigs and were randomly assigned to one of the three diets in a 2 x 3 factorial arrangement. Diets were a normal protein diet with 18% protein equilibrated for lysine (NP), a reduced protein diet with 14% protein corrected for lysine (0.8%) (RP), and a reduced protein diet with 14% protein not corrected for lysine (0.5%) (RL). The caloric value of the diets was 14 MJ/kg digestible energy. This trial was conducted under the guidelines for the care and use of experimental animals in INRB (Instituto Nacional dos

Recursos Biológicos). During the experimental period, animals were allowed to feed twice a day and water *ad libitum*. Throughout the experiment, pigs were weighted weekly just before feeding and slaughtered at an average live body weight of 93 ± 2 kg (INRB experimental abattoir). Feed was removed 17 h before slaughter. After electrical stunning and exsanguinations, samples from *longissimus dorsi* muscle were collected from the right carcass for IMF and shear force evaluations. All samples were vacuum-packed immediately and stored at -20 ºC. The pH and temperature were measured in the *longissimus dorsi* muscle at 45 minutes and 24 hours *post-mortem* at half the length of each loin, using a pH meter equipped with a penetrating electrode. The meat colour was measured at 24 h *post-mortem*, using a Minolta CR-300 chromometer and applying the CIE L*, a* and b* system 1 hour after air exposure to allow blooming. Intramuscular fat was extracted according to the Soxhlet method with previous acid hydrolysis [10]. After thawing during 24 h, the pieces of loin were grilled to an internal temperature of 70 ºC and 5–8 cores, parallel to muscle fibre direction, with 1 cm^2 of section were taken from each one. Shear force, expressed in kg, was measured in a texture analyser (TA-XT-plus Texture Analyser, Stable Micro Systems) equipped with a Warner–Bratzler shear device and data were collected with specific software (Texture Expert Exceed, Stable Micro Systems). The cooking loss was evaluated by weighing samples before and after cooking. The results were analyzed using the MIXED procedure of SAS version 9.1, (SAS Institute, Inc., Cary, NC, USA) with a model that included the main effects breed and diet and their interaction. The standard correlation was performed using the CORR procedures of SAS.

III. RESULTS AND DISCUSSION

The results for meat quality traits are shown in Table 1. Breed had a significant effect on temperature at 45 min (P<0.05), pH and shear force (P<0.01), as well as on L* (P<0.001) and a* (P<0.01) values, while dietary protein and lysine levels had no influence. Alentejano purebred compared to crossbred pigs showed higher initial pH values (pH_{45}) in *longissimus dorsi* muscle. However, the ultimate pH was not influenced by breed or diet. Moreover, the *longissimus dorsi* muscle from crossbred pigs tended to be paler (highest L* value; P<0.01) than those from Alentejano pigs. On the contrary, Alentejano breed had redder *longissimus dorsi* muscle (higher a* value; P<0.01) than crossbred pigs. A significant interaction (P<0.05) between breed and diet was observed for IMF content (2.2-5.8 g/100 g muscle), in which the RL diet increased the IMF in the crossbred pigs, whereas no dietary effect was observed for the Alentejano purebred. In addition, no difference was found in cooking loss when comparing breed and diets with normal and low protein levels with or without correction for lysine. These results agree with others [7], who found an increase in *longissimus dorsi* muscle marbling fat in pigs fed diets with low lysine levels (0.5% total dietary lysine) but not in animals fed high lysine levels (0.7 %). Others studies [5,11] showed that feeding pigs with reduced lysine diets in the finisher and grower phases increases IMF and improves the eating quality of pork. According to Doran et al. [7], one possible explanation for the increase in IMF content could be that lower dietary protein levels stimulate the expression of stearoyl-CoA desaturase (SCD), which in turn catalyses the cellular biosynthesis of monounsaturated fatty acids. In addition, a low-lysine (low protein) diet increases SCD transcriptional rate in pig muscles [12].

Table 2 depicts the correlations between pH, colour, IMF and shear force in *longissimus dorsi* muscle. Significant correlations between IMF content and L* and a* values (-0.311 and 0.446, respectively) were observed. Additionally, moderate correlations were found between meat colour coordinates. For instance, a negative correlation (r=-0.468) between L* and a* values was observed. On the other hand, a* values were positively correlated with b* values (r=0.623). As stated by [13], this positive relationship between yellowness and redness is surprising and difficult to explain, as these colour coordinates are usually inversely correlated. Although non-significant (P=0.06), IMF was negatively correlated with shear force. However, [14] reported the highest significantly negative correlation (r=-0.41; P<0.001) between IMF and shear force.

IV. CONCLUSION

The combined effects of dietary protein level, corrected or not for lysine, seem to have no influence on pig´s meat quality traits. In contrast, breed appears to have a strong effect on IMF content and lightness, with meat from Alentejano breed being tenderer than that from crossbred animals.

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Table 1 – Meat quality traits in the *longissimus dorsi* muscle of the Alentejano breed and Large White x Landrace x Pietran crossbred pigs.

	Alentejano			Crossbred			Significance levels		
	NP	RP	RL	NP	RP	RL	Breed	Diet	B x D
Temperature (ºC)									
45 min	30.84±0.32	30.86±0.43	31.09±0.47	30.12±0.37	29.91±0.18	30.48±0.31	*	ns	ns
24 h	10.07±0.53	9.05±0.44	9.35±0.43	8.53±0.61	9.25±0.54	8.64±0.53	ns	ns	ns
pH									
45 min	6.46±0.06	6.44±0.05	6.45±0.06	6.34±0.04	6.34±0.02	6.38±0.02	**	ns	ns
24 h	5.70±0.02	5.74±0.02	5.74±0.02	5.71±0.04	5.70±0.02	5.70±0.02	ns	ns	ns
Colour									
L*	49.40±1.21	50.05±1.49	50.47±1.66	55.95±1.65	54.87±1.87	54.22±1.58	***	ns	ns
a*	9.75±1.17	10.09±1.05	9.12±0.74	6.76±0.48	6.99±0.71	8.72±0.92	**	ns	ns
b*	4.59±0.64	4.73±0.42	4.56±0.60	4.12±0.48	3.79±0.41	4.66±0.55	ns	ns	ns
IMF (%)	4.16 ± 0.36^{b}	5.79 ± 0.92^{b}	4.47 ± 0.39^{b}	2.68 ± 0.28^{a}	2.16 ± 0.16^{a}	3.74 ± 0.35^{b}	***	ns	*
Shear force (kg)	5.96±0.39	5.87±0.32	5.97±0.41	7.24±0.61	7.15±0.35	6.53±0.55	**	ns	ns
Cooking loss (%)	14.36±1.22	14.10±1.20	14.12±1.16	15.53±1.22	16.26±1.18	13.86±1.25	ns	ns	ns

Significance: ns, *P*>0.05; **P*<0.05; ***P*<0.01; ****P*<0.001; means in the same row with different letters are significantly different (*P*<0.05); SEM, standard error of mean. NP – normal protein diet with 18% protein equilibrated for lysine, RP – reduced protein diet with 14% protein corrected for lysine (0.8%) and RL – reduced protein diet with 14% protein not corrected for lysine (0.5%). B x D – interaction between breed (B) and diet (D).

Table 2 – Correlations between temperature, pH 24 h, colour, IMF and shear force in the pork *longissimus dorsi* muscle.

Items	pH 24 h	Colour L*	Colour a*	Colour b*	IMF	Shear force
pH 24 h	1					
Colour L*	-0.137^{ns}	1				
Colour a*	-0.080^{ns}	-0.468^{***}	1			
Colour b*	-0.132^{ns}	0.208^{ns}	0.623^{***}	1		
IMF	-0.008^{ns}	-0.311^{*}	0.446^{***}	0.227^{ns}	1	
Shear force	0.114^{ns}	0.015^{ns}	-0.123^{ns}	-0.145^{ns}	-0.240^{ns}	1

Significance: ns, *P*>0.05; **P*<0.05; ***P*<0.01; ****P*<0.001.